



Bundesamt für Strahlenschutz

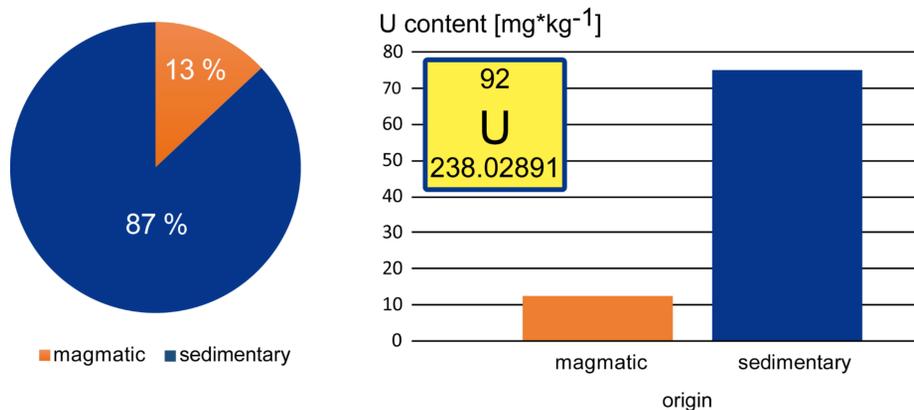
# Uranium in phosphate fertilizers

Dr. Michaela Achatz & Dr. Bernd Hoffmann, Bundesamt für Strahlenschutz, Köpenicker Allee 120-130, 10318 Berlin, machatz@bfs.de

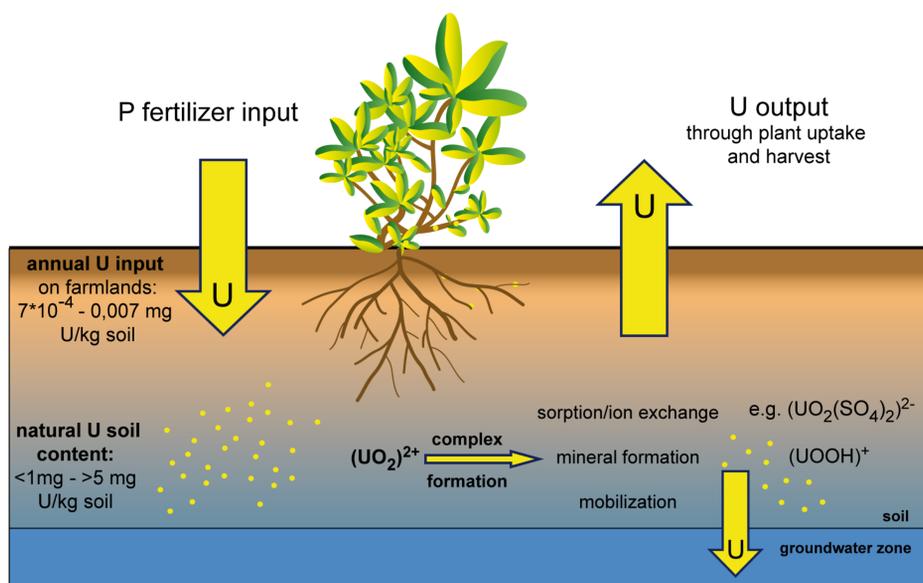
## Uranium in P fertilizers

87 % of mineral phosphate fertilizers are produced of **sedimentary rock phosphate**, which generally contains more heavy metals, especially **uranium**, than apatites of igneous origin [1].

mineral P fertilizers: origin and U content

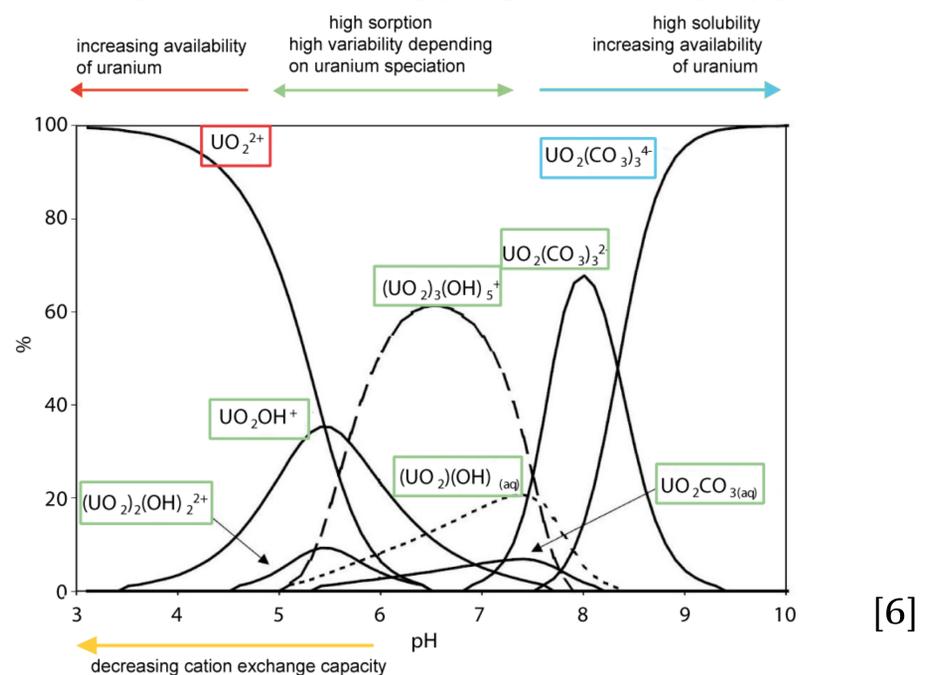


During **fertilizer production**, chemotoxic trace elements like **uranium** are transferred to the phosphate fertilizers, which are then applied on farmlands [2]. Uranium concentrations in phosphate rocks **fluctuate** from 8-220 mg U/kg raw material, depending on producers and parent rock material [1]. Consequently, the **annual uranium input** to farmlands varies also between  $7 \cdot 10^{-4}$  and 0,007 mg U/kg soil (= 2,3-23g/ha) depending on the fertilizer used [3]. Additionally the **soil** itself contains regional different amounts of U while there is in contrast a continuous **output** of U through plant uptake and harvest (<0.025 mg U/kg dry matter) [4].



## Mobility of uranium in soil

The solution and migration behavior of uranium is apart from its **redox ratio**, determined by its **pH** conditions as well as its **ligand quality** and **quantity** (e.g. carbonates, phosphates, DOC). The influence of pH conditions on U is based on two mechanisms: both **uranium speciation** and **charge character** of soil components are strongly dependent on pH [5].



A further role play potential **soil components** like clay minerals, pedogenic oxides and soil organic matter [7].

## Modelling of uranium mobility

To provide a speciation model of U in soil e.g. in PhreeqC, several components have to be included: first you have to chose a suitable **database**, including all relevant chemical and physical **reaction constants**. The next important factor is to correlate sorbing soil compartments to established **complexations- or exchange models** (e.g. Bradbury & Baeyens for sorption on clay minerals, Tipping for dissolved organic matter) and the quantification of the different sorption positions. These data together result in a **PhreeqC input file**.

**Modelling of uranium inputs and its further disposition in soil** can help to elucidate the final occurrence of uranium in groundwater and support the evaluation of its **chemotoxicity**.

## References:

- [1] Merkel BJ, Hasche-Berger A, Kratz S, Schnug E, 2006, Rock phosphates and P fertilizers as sources of U contamination in agricultural soils, in Uranium in the Environment, Springer Berlin Heidelberg, 57-67
- [2] Dienemann C, Utermann J, 2012, Uran in Boden und Wasser, Umweltbundesamt, <http://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/4336.pdf>
- [3] Kok LJ, Schnug E (Eds.), 2008, Loads and fate of fertilizer-derived uranium, Backhuys Publishers, Margraf Publishers, Leiden, Weikersheim, Germany, 229
- [4] Kratz S, Knappe F, Schnug E, 2008, Uranium balances in agroecosystems, in Loads and fate of fertilizer-derived uranium, Backhuys Publishers, Leiden, Weikersheim, Germany, pp. 78-90
- [5] US-EPA, Understanding variation in partition coefficients,  $K_p$ , Volume II: Review Of Geochemistry And Available  $K_p$  Values For Cadmium, Chromium, Lead, Plutonium, Radon, Strontium, Thorium, Tritium and Uranium, Washington, USA
- [6] Giammar, D, 2001, Geochemistry of uranium at mineral-water interfaces: rates of sorption-desorption and dissolution-precipitation reactions, California Institute of Technology
- [7] Dong W et al., 2005, Influence of calcite and dissolved calcium on uranium (VI) sorption to a Hanford subsurface sediment. Environmental science & technology, 39(20): p. 7949-7955